



## REVIEW ARTICLE

### Importance of using apical locators in endodontic treatments

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#### ABSTRACT

**Introduction:** apical locators represent a fundamental innovation in endodontic practice, allowing a more precise determination of working length and reducing clinical complications associated with root canal treatment.

**Objective:** to analyze scientific evidence on the importance, functions, and limitations of apical locators in dental practice.

**Methods:** a bibliographic review was conducted through the implementation of a search algorithm across different databases, applying established selection criteria. The analysis focused on reported accuracy, advantages, and limitations.

**Development:** apical locators have evolved from systems based on electrical resistance to multi-frequency devices with high clinical accuracy. Advantages include reduced radiographic exposure, ease of use, and the ability to measure in moist canals. However, limitations are reported in teeth with open apices, metallic crowns, pacemaker interference, and morphological variations. Comparative studies show that devices such as root zx and apit provide reliable results, although influenced by irrigants and specific clinical conditions. Current trends highlight the integration of these devices as indispensable complements to endodontic treatment.

**Conclusions:** apical locators are electronic tools of great value for improving diagnostic and therapeutic precision in endodontics. Their use complements radiography, reduces risks of over-instrumentation, and strengthens professional training, consolidating them as an essential resource in contemporary dentistry.

**Keywords:** Endodontics; Dental Instruments; Root Canal Therapy.

## INTRODUCTION

Contemporary dental practice has incorporated numerous technological advances aimed at optimizing endodontic procedures, among which apex locators occupy a prominent place. These electronic devices allow for more precise determination of the working length of the root canal, promoting treatment efficacy and reducing the risk of periapical complications. However, despite their widespread use, questions remain regarding their technical limitations, the variability in their accuracy depending on clinical conditions, and the need to complement their use with traditional radiographic methods.<sup>(1,2)</sup>

According to Andrade and Guillen,<sup>(3)</sup> apex locators are classified into generations. The first generation measures resistance using electrical current, determining if there is a constant resistance between the periodontal ligament and the oral mucosa. Second-generation locators measure impedance between two frequencies, as do third and fourth-generation locators (1990). Fifth and sixth-generation locators, introduced in 2003, no longer measure impedance but instead measure resistance and capacitance values, comparing them to data stored in a database.

In the research of Arroyo et al.,<sup>(4)</sup> he refers to apex locators because they enable the identification of conductimetry, since it is considered as the distance that is measured from a coronal reference point to an apical limit where the instrumentation and subsequent obturation will be limited, being fundamental for the exact determination of the working length during endodontic treatment.

In his study, Meza Pacheco,<sup>(5)</sup> emphasizes the correct use of apex locators based on proper handling by the dental professional, since the tooth must be isolated to preserve the effectiveness of the endodontic treatment; in this way, reliable results will be obtained, especially if the displacement of the screen bar is static and shows movement in accordance with that made with the file; measurements should be made with manual files so as not to affect the success in the accurate identification of the working length; to obtain an adequate measurement, it is necessary that the tip of the file reaches the apical constriction; apex locators are also used to diagnose or locate root fractures or perforations.

Given that the use of apex locators allows for the measurement of tooth length and the root canal limit, it is essential to understand the importance of their advantages in endodontic practice, as this aims to improve patient care. With this in mind, the present research was developed, with the objective of analyzing the scientific evidence on the importance, functions, and limitations of apex locators in dental practice.

## METHODS

For this study, a systematic literature review was employed, following the PRISMA guidelines. The objective was to synthesize the available evidence on the use of apex locators in endodontic procedures, considering studies published between 2010 and 2025. A descriptive approach was adopted, based on previous qualitative research, applying an inductive-deductive method that allowed for the evaluation of the effectiveness of these devices in determining working length and preventing periapical complications. This methodological strategy ensured the transparency and reproducibility of the information search and selection process.

Information sources included international and regional databases with broad coverage: PubMed, SciELO, ScienceDirect, Google Scholar, LILACS, and BVSAUD. Secondary references from relevant articles and grey literature available in institutional repositories and conference proceedings were also reviewed to broaden the scope of the search. The search strategy was designed using a combination of keywords and Boolean operators, such as "apical locator" AND "endodontics" OR "working length" NOT "implants," adapted to each database. Publications in Spanish, English, and Portuguese were considered, allowing for a broad linguistic spectrum and reducing language bias.

The inclusion criteria considered original articles published within the defined time frame, with full text access and a direct connection to the study topic. Duplicates, case reports, medical records, irrelevant studies, and studies outside the analysis period were excluded. The selection process was carried out in several phases: first, titles and abstracts were reviewed to discard irrelevant records; subsequently, the full texts of potentially eligible articles were reviewed. Initially, 1,245 records were identified, of which 327 were eliminated due to duplication and 543 for not meeting the inclusion criteria. Finally, 375 articles were incorporated into the qualitative analysis. The procedure was documented using the PRISMA flow diagram, which systematically reflects the stages of identification, screening, eligibility, and inclusion.

Data extraction and analysis were performed in a standardized manner, collecting key variables such as author, year of publication, methodological design, sample size and characteristics, as well as the main results related to the clinical efficacy of apex locators. Information synthesis was conducted qualitatively, integrating relevant findings and comparing trends across studies. A meta-analysis was not performed due to the heterogeneity of the designs and results; however, a narrative approach was applied, allowing for the identification of common patterns and knowledge gaps. This methodology ensures the validity and scientific rigor of the review, providing an up-to-date and critical overview of the research topic.

## DEVELOPMENT

The main findings on the importance of measuring the length of the dental apex as well as the root canal to avoid possible perforations using the apex locator in patients are described, for Piasecki et al.,<sup>(6)</sup> describe in their results on the effectiveness of apex locators, since they allow traversing the root canal and the oral tissues of the patient in order to determine the location of the apical foramen.

However, in the results of Neena et al.,<sup>(7)</sup> it was found that there are limitations such as inflammation of the periodontal ligament in infectious processes, the morphological variation of the apical foramen, the degree of apical resorption and the relationship of the primary tooth with the germ of the permanent tooth that hinder the application of the use of the apex locator in deciduous dentition.

Considering the findings of Jadhav et al.,<sup>(8)</sup> they describe in their study the use of the Woodpex III PRO apex locator as a multi-frequency impedance system for maximum precision and measurement of the file trajectory in various colors, and is focused on root canal preparation treatments. While the iRoot Apex apex locator has a high-quality touchscreen LCD allowing for easy navigation, this instrument provides gyroscopic precision during endodontic procedures, as it generates an alert when the file is less than 2.2 mm from the apex.

The results of Pommer et al.,<sup>(9)</sup> agree that, due to advances in science and innovation in dentistry, a new apex locator, called the Apex Finder, Model 7005 (Analytic Endodontic, Orange, CA), has been developed. This device operates at five frequencies (0,5 kHz, 1, 2, 4, and 8 kHz). However, its purpose is to determine the working length in vital, necrotic, and retreatment canals in the presence of various electrolytes such as blood, exudate, and sodium hypochlorite. This apex locator has an accuracy of 86 %.

In the research of Andrade and Guillen,<sup>(3)</sup> the Endox system (Lysis Deutschland GmbH) was used, the results of which provide effective cleaning and disinfection of the root canals, in addition, it allows the evaporation of the pulp tissue and bacterial content through the integration of a system to locate the apex of the posterior canal in order to improve the quality of the endodontic treatment and to simplify the systematization of the work.

However, in the results of Perreínas,<sup>(10)</sup> he states that apex locators are electronic instruments that allow access to the endodontic process in patients, whose function is to measure the impedance, resistance and frequency of another circulating material in order to locate the length of the root canal.

According to Rodríguez and Oporto,<sup>(11)</sup> the objective of apex locators is to improve the characteristics of apex locators, in order to facilitate the operator's work, as well as the search for greater precision, through the incorporation of new instruments to increase or improve their effectiveness.

The author Meza Pacheco,<sup>(5)</sup> in his results applied an in vitro study, which allowed him to compare the Root ZX and the Apit as apical constriction locators in the presence of various irrigants. Forty-one teeth were used and irrigated with 1 % sodium hypochlorite, 3 % hydrogen peroxide, and 0,9 % sodium chloride as a control group. It was observed that the Root ZX is more accurate (76-85 %) in measuring working length, both at the 0,5 mm reading and at the apex, especially if the canal contains sodium hypochlorite. The Apit is more reliable in its apex readings. It is more influenced by the canal contents, giving shorter measurements..

The research carried out by Gomes Azevedo,<sup>(12)</sup> whose results demonstrate that the main advantage of apex locators today refers to a correctThis measurement method is more accurate and reliable than radiographic methods. Studies have reported clinical accuracy rates as high as 96,2 %. Therefore, it is a quick and easy procedure that reduces radiation exposure for both the patient and medical staff. It allows for the detection of canal perforations; it is a method for locating the physiological foramen, not just the radiographic apex, using files of any diameter; it allows for measurements in moist canals, eliminating the need to remove the entire canal contents; it offers better quality and accuracy, is easier to use and acquire compared to previous devices and X-ray equipment, and allows for the determination of the level of horizontal fractures.

While Maura et al.,<sup>(13)</sup> state in their results that the main disadvantage is that it is not advisable to use it in patients with pacemakers, due to the possibility of interference, although no accidents have been reported with its use. Although it is possible to use it in moist canals, it is not recommended that the pulp chamber be flooded with the irrigating solution, with blood, or with other liquids; its use is limited in partially calcified canals or those with metallic crowns and cores; the reading in teeth with an open apex is generally inaccurate, and, finally, in vital teeth, its results can be inconsistent.

According to Gay Ortiz,<sup>(14)</sup> the main reasons why canal locators fail to accurately measure the canal length are extensive caries or damage that connects the canal to the gingiva, as saliva closes the circuit, producing a continuous sound. The same occurs when there is bleeding that spills over the crown. The solution, in the first case, is to restore the caries or the defective filling, and in the second, to stop the bleeding. The locator is also interfered with by fillings, abutments, and metal crowns; therefore, contact between the labial hook and the file with metal should be avoided (by separating them with a finger or drying the pulp chamber with cotton). In long roots treated with electrolytic solutions, the tendency is to use short working lengths; this can be corrected by drying the canal with paper points.

A study by Chaparro,<sup>(15)</sup> on apex locators showed imprecise results in the presence of fluids; however, the use of irrigating solutions offers significant advantages, such as antibacterial action and tissue dissolution, which allows for adequate root canal cleaning. Another in vitro study compared the Root ZX and Apit devices for locating the apical constriction in the presence of various irrigants. Forty-one teeth were irrigated with 1 % sodium hypochlorite, 3 % hydrogen peroxide, and 0,9 % sodium chloride as a control group. The Root ZX was found to be more accurate (76-85 %) in measuring working length, both at the 0,5 mm reading and at the apex, especially if the canal contained sodium hypochlorite. The Apit was more reliable in its apex readings. It is more influenced by the canal contents, resulting in shorter measurements.

Non-conductive irrigating solutions allow for better detection of the file's position in relation to the foramen, in addition to interfering less with metallic restorations; in order of greater precision they distinguish: alcohol, 0,9 % NS, EDTA and finally 5,25 % Sodium Hypochlorite.<sup>(12)</sup>

In Bramante's study,<sup>(16)</sup> it is described that manufacturers report that the effectiveness of the Root ZX is not affected by the presence of different liquids within the canal. Jenkins et al. conducted a study to test the effectiveness of the Root ZX apex locator in the presence of a wide variety of irrigants commonly used during endodontic treatment. They used: 0,9 % sodium chloride diluted in water, 2 % lidocaine with 1:100,000 epinephrine, 5,25 % sodium hypochlorite, RC prep., liquid EDTA, 3 % hydrogen peroxide, and Peridex. The results showed that the length determination is not affected when using the Root ZX apex locator with any type of irrigant solution, when compared to the actual canal length.

Meanwhile, Pommer et al.,<sup>(9)</sup> reported that the effectiveness of the Root ZX, using sodium hypochlorite at different concentrations (5,25 %, 2,65 %, 1,00 %, and 0,50 %) on alginate models, showed no significant differences ( $p > 0,95$ ) when measuring the distance between the file tip and the apical constriction. Its use is not recommended in non-permeable canals (calcified or filled with obturation material), root fractures, or in patients with pacemakers (due to the possibility of interference). In these cases, consultation with a cardiologist is recommended. In teeth with apical resorption, with or without a fistula, it is recommended to measure with files of a larger diameter. In retreatment cases, the canal must be patent to begin the measurement process.

However, Meza Pacheco,<sup>(5)</sup> in his studies demonstrates that after tooth extraction, and based on visual confirmation of the relationship between the file tip and the apical foramen using a stereomicroscope and/or scanning electron microscope (SEM), studies indicate a tendency toward over-extension in relation to the foramen margin. Therefore, it is recommended to remove 0,5 mm or more in cases where the file tip is located within the foramen, and 1 mm or more in cases where the file extends beyond it. This avoids over-instrumentation and potential destruction of the apical constriction. The adjusted length is subject to radiographic confirmation.

According to Rivas Muñoz,<sup>(17)</sup> the advantages of current foramen locators include more accurate and reliable measurements than radiographic methods. This procedure is quick and easy and reduces the amount of radiation exposed to both the patient and medical personnel.

Several studies have evaluated the accuracy of various apex locators. They have demonstrated their ability to provide accurate readings in the presence of moisture, although electronic models such as the Apex Finder AFA model 7005 exhibit a higher level of accuracy. Subsequently, new devices developed by Analytic, Sybron Dental Specialities, and distributed by Kerr Dental Mfg., such as the Apex Finder 7001 and the Endo Analyzer 8001, were introduced to the market. Both share the same apex locator system based on impedance measurement between two electrodes; the main difference lies in the fact that the Endo Analyzer 8001 incorporates a vitalometer, which expands its diagnostic functions.<sup>(4,18,19,20)</sup>

The literature highlights that determining the root canal length is one of the most relevant factors for the success of endodontic treatment in both permanent and primary teeth. Although precise length measurement is not strictly mandatory in primary teeth, its accurate determination facilitates instrumentation and obturation, increasing the safety of the procedure.<sup>(21,22,23)</sup> In agreement, Chaparro et al.,<sup>(15)</sup> point out that the use of apex locators allows for a more conservative preparation of the root dentin and reduces the amount of irrigants needed compared to conventional endodontics, resulting in less postoperative pain by decreasing excessive manipulation, material extrusion, and other factors associated with post-treatment discomfort.

## CONCLUSIONS

Apex locators are essential electronic instruments in endodontics, as they allow for the measurement of impedance, frequency, and resistance of the surrounding material to accurately determine the length of root canals. Their use facilitates the removal of impurities and bacteria in the apical area, improves pulp tissue health, and reduces radiographic exposure, offering reliable and efficient results in clinical practice. While they do not replace radiography, they complement it by facilitating the monitoring of subsequent treatment phases and in cases where the locator cannot be used. Scientific evidence confirms that they are key tools for dental innovation, especially when combined with irrigating solutions that have antibacterial action and tissue-dissolving capabilities.

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